
Expert Report of Steven P. Larson

***State of Oklahoma et al. vs.
Tysons Foods, Inc. et al.
U.S. District Court for the
Northern District of Oklahoma
Case No. 05-CV-329-GFK-SAJ***



S.S. PAPADOPULOS & ASSOCIATES, INC.
Environmental & Water-Resource Consultants

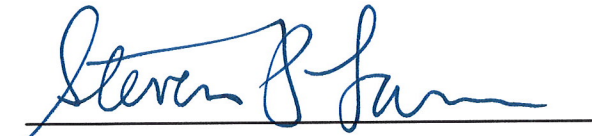
November 25, 2008

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- Figure 11 Graph of Dissolved Copper Concentration in Groundwater Samples versus Active Poultry House Density
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Section 1

Introduction

This report was prepared by Steven P. Larson. I am a hydrologist with S. S. Papadopoulos & Associates, Inc. (SSP&A), specializing in groundwater. I have a bachelor's degree and a master's degree in civil engineering from the University of Minnesota. I worked as a hydrologist for the Water Resources Division of the U. S. Geological Survey for about nine years prior my work at SSP&A. I have spent the past 28 years at SSP&A working on a variety of water resource and environmental projects. Many of those projects have involved soil and groundwater contamination and the fate and transport of contaminants through the subsurface environment. I am registered as a Groundwater Hydrologist with the American Institute of Hydrology. I have published papers concerning water resources and groundwater contamination in various journals and other publications. I have made presentations to various technical and non-technical forums regarding my work on water resource and environmental problems. I have provided expert testimony in numerous legal matters and in many different forums, including testimony in a case before the United States Supreme Court. My resume and list of publications and testimony, along with my compensation in this matter are provided in the appendix to this report.

I was retained by the defendants in this case to evaluate groundwater conditions as they relate to claims made by the plaintiff. To conduct my evaluations, I have reviewed numerous reports, documents, and data related to the Illinois River basin. I have also reviewed information and data in a variety of historical reports published by researchers or other investigators evaluating groundwater conditions and groundwater quality both within and outside of the Illinois River basin. I have also reviewed some of the reports prepared by plaintiff consultants. I have also visited the basin and inspected some of the specific spring and well locations that were sampled by plaintiff consultants.

As a result of my review and evaluation of the information and data described above I have developed a number conclusions and opinions regarding groundwater conditions in the Illinois River basin and regarding the conclusions and opinions of some of the plaintiff consultants. My opinions and conclusions are outlined below followed by a narrative discussion that elaborates on the bases for my opinions and conclusions.

Section 2

Summary of Conclusions and Opinions

Outlined below is a summary of the conclusions and opinions that I have developed in this case.

1. The relationships of phosphorus, zinc, copper, and arsenic in groundwater and spring samples presented by Fisher on Figure 22 of his report do not lie along a common line with the relationship for edge of field samples. In fact, the relationships among these elements in edge of field samples are very different from the relationships in groundwater and spring samples. The statement on page 52 of his report that the edge of field samples "blend seamlessly" with results from groundwater samples is not true. Under Fisher's apparent definition of "blend seamlessly," any sample with low concentrations of the different elements would qualify regardless of the actual relationship between the concentrations.
2. The high correlation shown on the cross plots presented by Fisher on Figure 22 of his report is misleading. This high correlation is created by one anomalous edge of field sample that has values of phosphorus, copper, and zinc that are significantly higher than any of the other edge of field samples and all of the groundwater and spring samples. Without this single sample, the computed correlation coefficient is much lower. Olsen (page 8-41) comments on the anomalous nature of this particular edge of field sample and removes the sample as an outlier in his PCA analysis. Fisher, however, has retained the sample and this sample's values create the apparent high correlation shown on his figures.
3. Groundwater sample results show little or even negative correlation with measures that are claimed to be indicators of potential impacts of poultry litter on groundwater quality. Poultry house density is not significantly correlated to parameters such as phosphorus, zinc, copper, and others that are claimed to be associated with poultry litter and, in many cases, the correlation is negative. Similar results are found when comparing groundwater concentrations with distance to nearby poultry houses. The lack of significant correlation with these measures shows that the groundwater sampling data do not provide a link between the occurrences of various constituents in groundwater such as phosphorus, copper, zinc, or total coliform and the existence of poultry houses.
4. Bacterial contamination and nitrate contamination are a common occurrence in groundwater samples from hydrogeologic environments such as those found in the Illinois River basin. This common occurrence is a result of many sources of bacterial contamination and nitrate contamination and cannot be linked to one specific source. As population and urbanization increase, the potential for bacterial contamination and nitrate contamination increases.
5. The frequency of occurrence of bacterial contamination in groundwater from wells sampled by the plaintiff consultants is similar to or less than that found in other karst aquifers in the United States. This frequency has not increased over the past forty years.



6. Groundwater flow in karst terrain such as the Illinois River basin can be very localized. That is, much of the groundwater that emerges from springs or is removed by wells is likely to have entered the groundwater environment within a relatively short distance from the location of discharge or withdrawal. As a result, contaminants found in the groundwater samples from such locations are much more likely to have resulted from processes occurring near the sampling location than from greater distances.
7. Septic tanks, which are used by over 76,000 residents in the Illinois River watershed, are a significant source of localized groundwater contamination. Septic tanks are a source of nitrate and bacteria to groundwater. The failure rate for septic tank systems within the Illinois River watershed is significant. The Illinois River Basin Plan indicates that it is likely that as many as 75% of the on-site waste disposal systems are inadequately constructed or located (Haraughty, 1999). A survey of septic systems in Tontitown and Highfill, Arkansas, indicated that 74 out of 171 septic tank systems (43%) had some type of reported failure (Engineering Services, Inc., 2004). The rate of failure indicated by these studies is much higher than the 8% failure rate assumed by plaintiff consultant Teaf.
8. Septic tank effluent has a significant potential to impact groundwater. Septic tank effluent that is discharged to drain fields constructed below the land surface is not as prone to evaporation as rainfall that falls on the land surface would be. Furthermore, the thickness of the soil profile between the discharge point and the groundwater is smaller than the total soil profile thus providing less opportunity for attenuation within the soil column.
9. Phosphorus concentrations found in groundwater samples from wells in the Illinois River basin are typical of concentrations found in karst groundwater environments. The concentrations are within the range of and generally lower than concentrations typically found in this type of groundwater environment in other parts of the United States.
10. Plaintiff consultant King, in his report, assumes that 60 percent of the groundwater wells in the Illinois River basin have been impacted by poultry operations and, as a result, would require some form of treatment or replacement. The assumption that 60 percent of the wells in the basin have been impacted by poultry operations has no basis. Furthermore, since each well that King utilized as a sample population was not resampled, the sampling data do not provide a reliable indicator of whether treatment or replacement of wells is even necessary because the USEPA criteria for determining impact due to total coliform detection are, at least in part, based on frequency of detection over time.
11. Plaintiff consultant Olsen attempts to characterize impacts to groundwater samples based on a principal component analysis. Olsen's subjective assignment of principal component values is not a reliable indicator of impacts to groundwater. Furthermore, Olsen's characterization of groundwater samples with regard to impacts from poultry operations is inconsistent with the assumptions made by King regarding the number of wells impacted by poultry operations.



12. Nutrient management practices, as adopted or utilized in nutrient management plans for poultry litter application to fields in Oklahoma and Arkansas, significantly reduce the potential for impacts to groundwater from the application of poultry litter.

Section 3

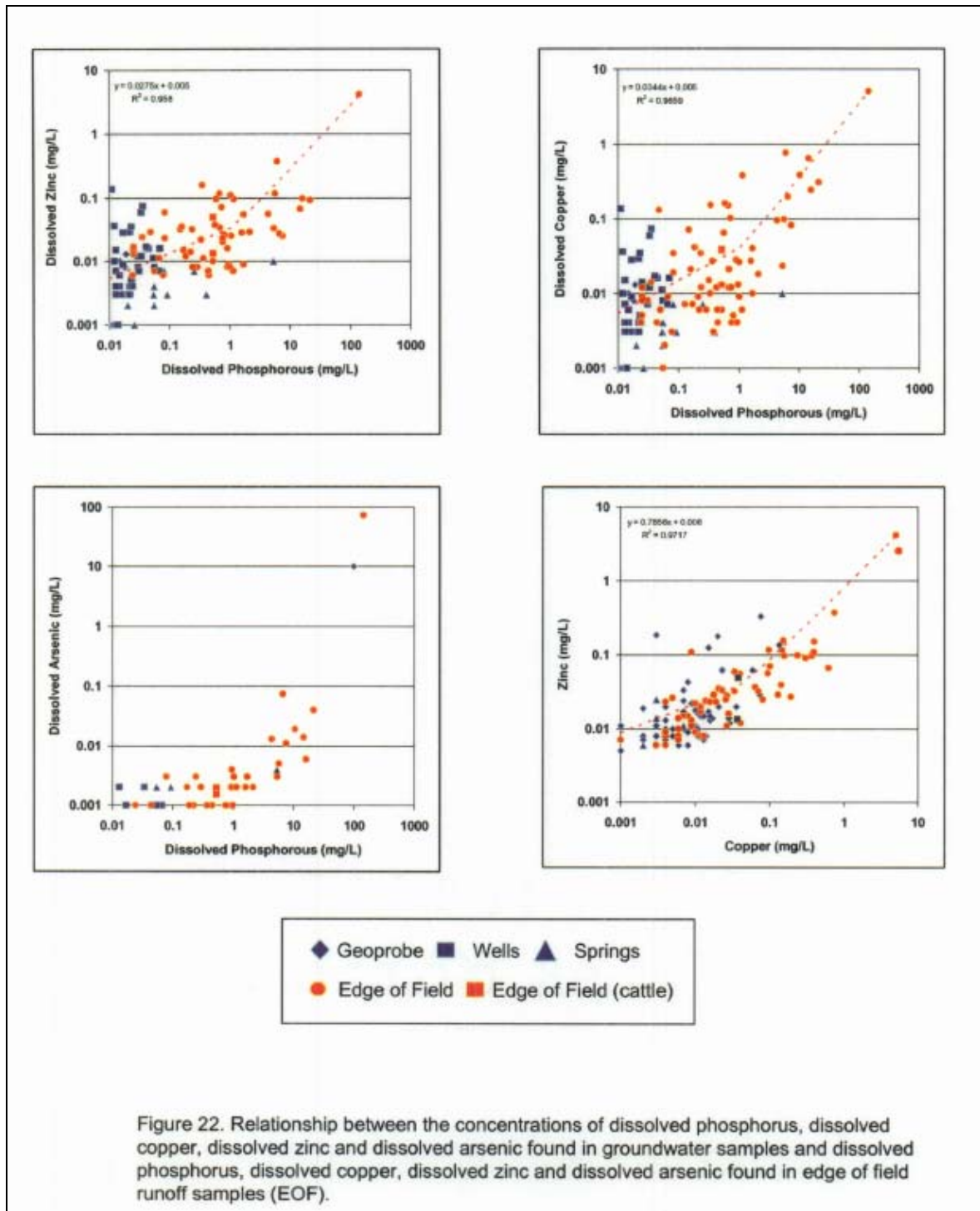
Bases for Opinions

The Springfield Plateau Aquifer is an unconfined aquifer; the water table generally occurs within the aquifer unit. Groundwater discharge from the aquifer sustains the stream flow in many of the perennial creeks and streams within the Illinois River basin. Many of the creeks and streams are aligned with fault or fracture zones, and these zones have an influence on groundwater flow patterns. Groundwater recharge occurs in the upland areas and the distance from an area of recharge to an area of discharge is generally on the order of a few miles or less. As a result, most groundwater is derived from local recharge. Studies by the U. S. Geological Survey (Adamski, 2000) of the Springfield Plateau Aquifer have indicated that the minimum average age of groundwater is on the order of 2 to 6 years. That means that it takes, on average, at least about 4 years for water to flow from an area of recharge to an area of discharge.

Groundwater quality in the Springfield Plateau Aquifer is generally dominated by calcium bicarbonate. This is a result of the primary geochemical process in the aquifer being one of carbonate rock dissolution (Adamski, 2000). Concentrations in groundwater of various trace metals such as arsenic, copper, and zinc are generally less than 0.1 mg/L. Concentrations in groundwater of phosphorus are also low, on the order of 0.1 mg/L or less. Concentrations of nitrate can be somewhat elevated and exceed 10 mg/L in some areas (Adamski, 1997, WRI 96-4313).

The unconfined nature of the Springfield Plateau Aquifer makes it susceptible to impacts from surface and near-surface sources of contamination. Septic tanks and infiltration fields, effects of urbanization, agricultural activities and operations, and various industrial activities all have the potential to impact groundwater quality in the aquifer. Numerous studies have shown that septic systems can impact groundwater (USEPA, 2002). Other studies have shown the potential for urban and agricultural land use to impact surface runoff and groundwater quality (Galloway, et. al., 2005, SIR 2005-5140; Adamski, 1997, WRI 96-4313). Waste discharges from various industrial sources can also impact surface water and groundwater.

In his report, Fisher (page 52) contends that groundwater within the Illinois River Watershed is contaminated by poultry litter. To try to support that contention, he refers to Figure 22 of his report that displays the relationships between concentrations of dissolved phosphorus, dissolved copper, dissolved zinc, and dissolved arsenic in samples of groundwater and samples of edge of field runoff. This figure is shown below.



On three of the graphs shown on Figure 22, Fisher draws a line representing the best fit linear relation of the plotted data and provides the equation of that linear relation along with the correlation coefficient associated with the linear relation. He describes the graphs as “show[ing]

that the concentration relationships found for edge of field samples blend seamlessly with those found in groundwater samples."

Fisher's characterization of the data on these graphs is not true. The apparent strong linear relation given for the edge of field samples does not hold for the samples taken from wells, springs, and geoprobes. The validity of the apparent strong linear relation for edge of field samples will be discussed further below but examination of the data sets for wells, springs, and geoprobes shows that those linear relations are completely different from the apparent linear relation for the edge of field samples.

For example, if we examine the relationship of dissolved copper and dissolved phosphorus for each of the data groups, we find significantly different linear relations as shown on the figures below.

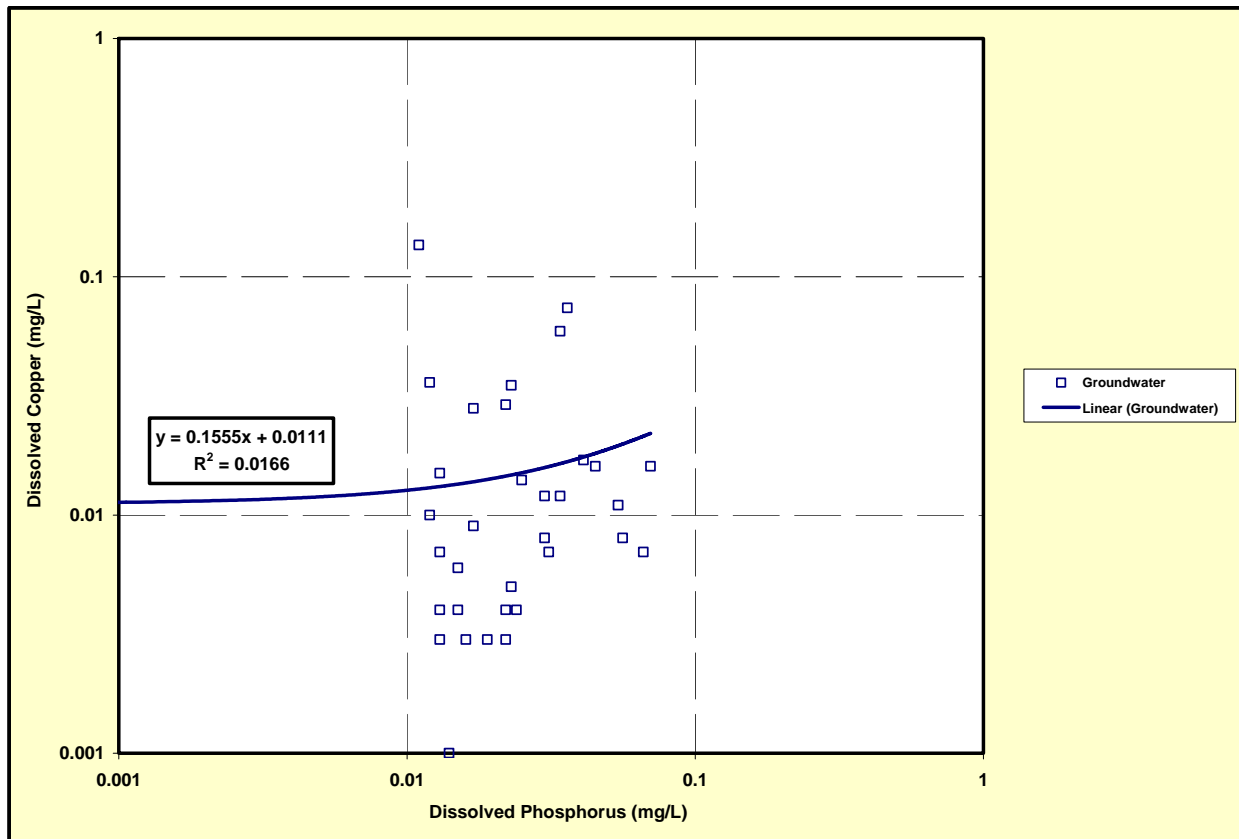


Figure 1 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Groundwater Samples

The graph on Figure 1 shows the dissolved copper and dissolved phosphorus concentrations for only the groundwater samples. Visually, there is no apparent relationship

between the copper concentrations and the phosphorus concentrations. The best fit line through the data confirms the visual observation. The low value of the coefficient of determination (R^2) statistic indicates that there is essentially no linear relationship exhibited by this set of groundwater data. Figures 2 and 3 below for samples from geoprobes and springs, respectively, also show either a lack of a relationship or a relationship that is different from the edge of field samples. Note that on these figures, which are plotted using logarithmic scales to be consistent with Fisher's Figure 22, do not show points where either one or the other of the concentrations was below the detection limit. The linear regression line, however, was determined using all of the data values, including the values reported as non-detect.

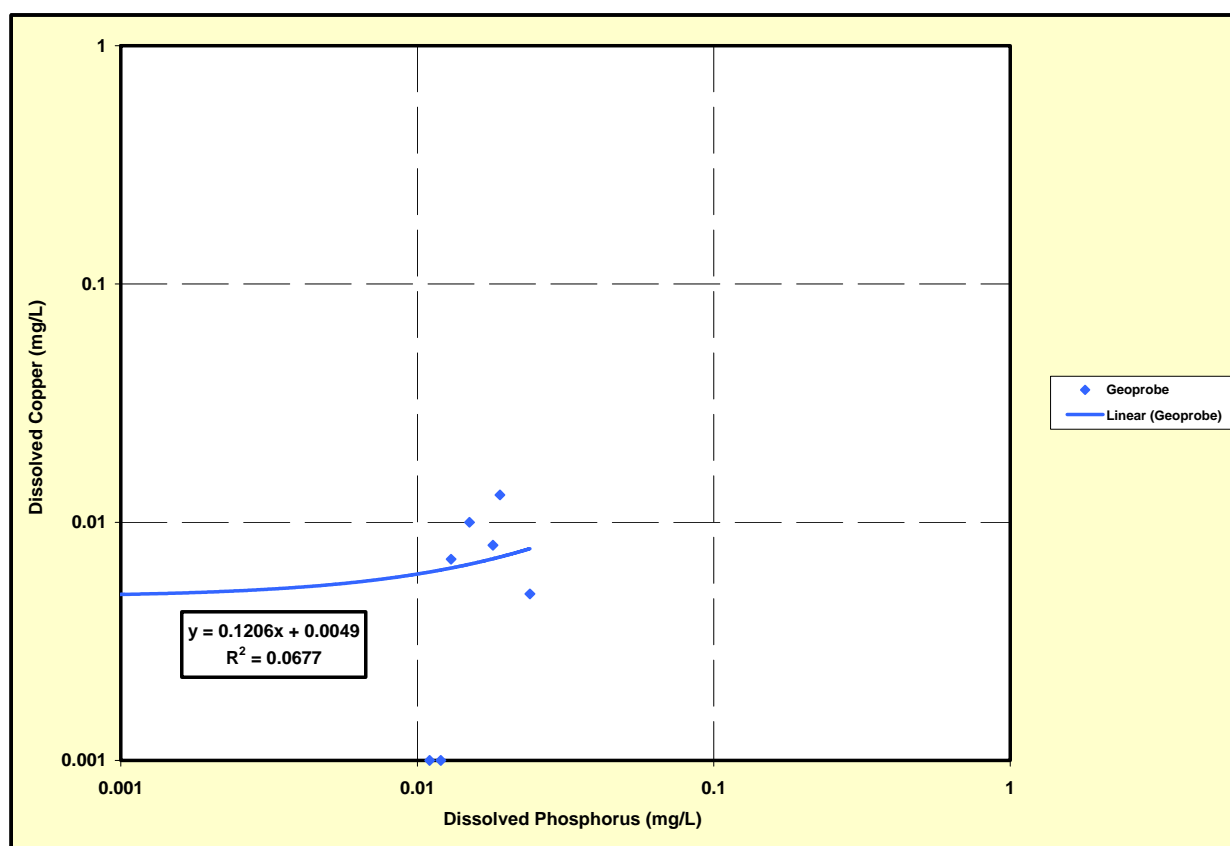


Figure 2 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Geoprobe Samples

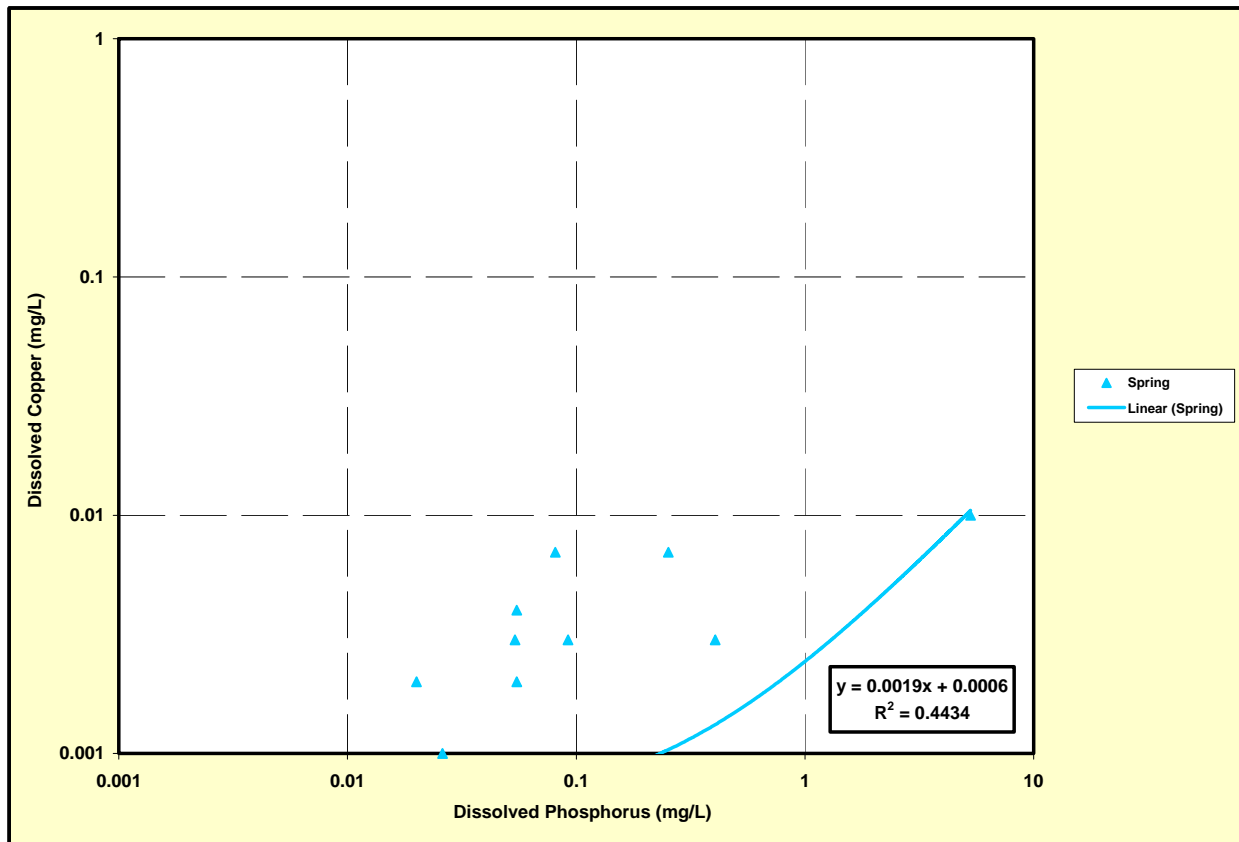


Figure 3 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Spring Samples

The lack of a relationship or the difference in relationship between copper concentrations and phosphorus concentrations as shown on Figures 1 through 3 is obscured in Fisher's Figure 22 because it portrays the relationship of several different sets of data that are dominated by the edge of field samples as discussed below.

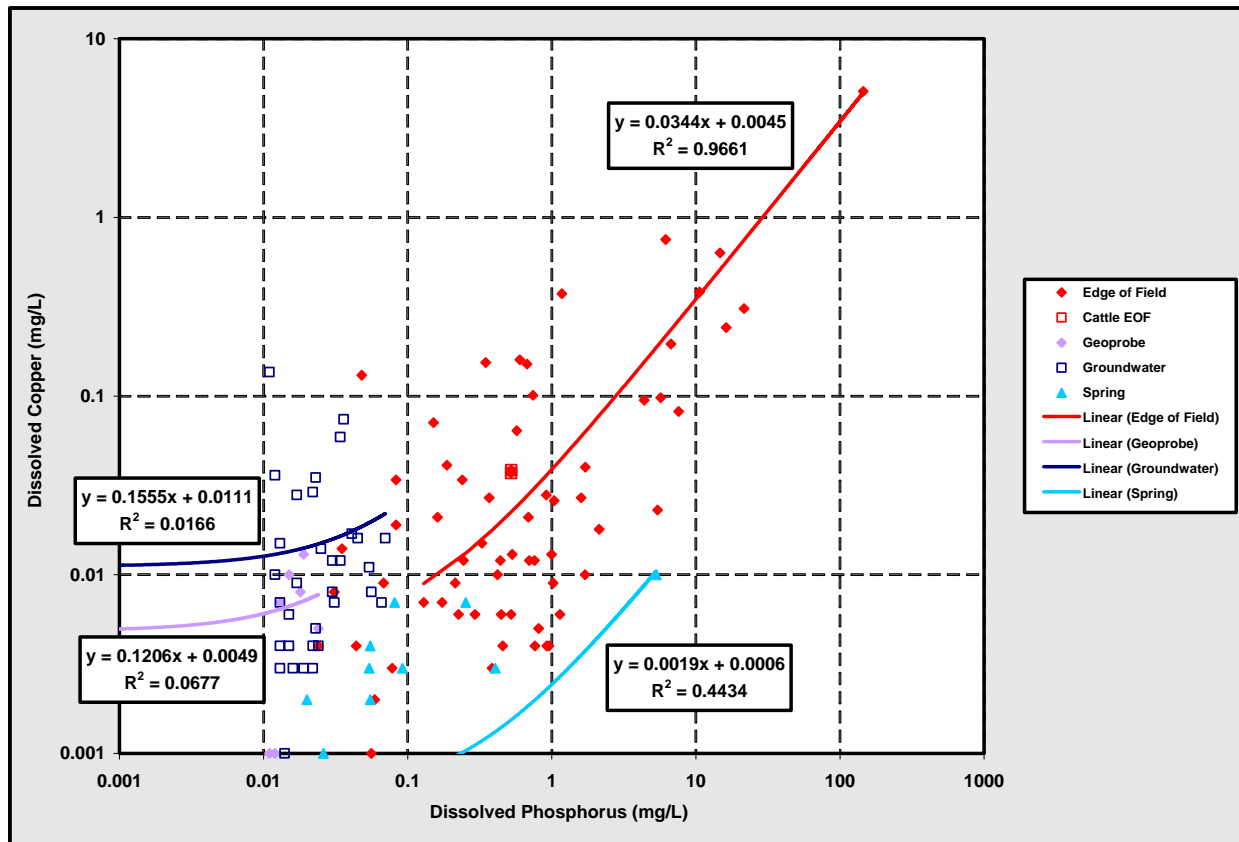


Figure 4 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Edge of Field, Geoprobe, Groundwater and Spring Samples

Figure 4 shows the data points for all of the sample groups and the different linear relationships for individual groups. In this figure, each of the different groups of samples shown on Fisher's Figure 22 has been analyzed separately. As discussed previously, the data on this figure illustrate that the groundwater and geoprobe data have virtually no linear correlation and the linear relations for groundwater, spring and geoprobe samples are all different from the linear relation for the edge of field samples.

The same lack of correspondence in the relationships is shown for the other graphs presented by Fisher on his Figure 22. For example, the linear relationships for dissolved zinc and dissolved phosphorus are shown on Figure 5 below.

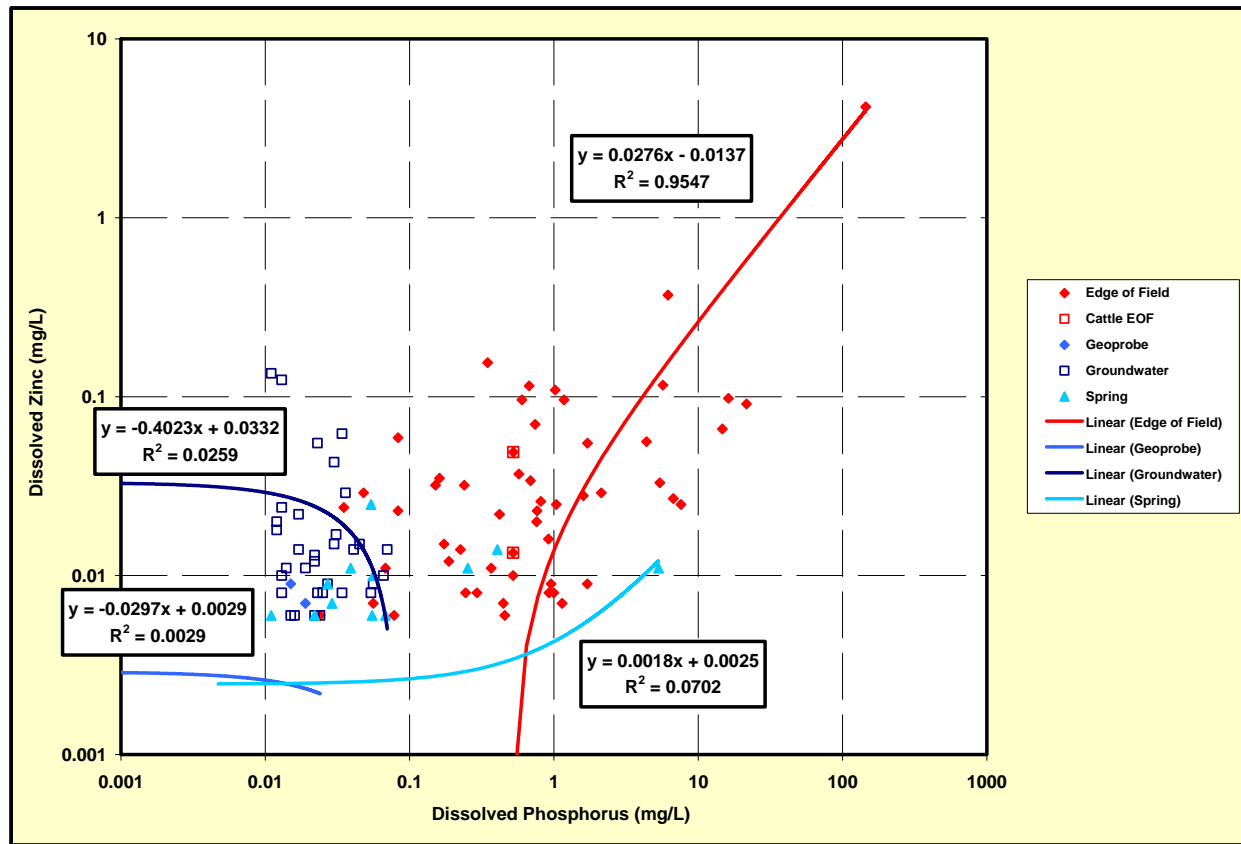


Figure 5 – Graph of Dissolved Zinc versus Dissolved Phosphorus Concentrations in Edge of Field, Geoprobe, Groundwater and Spring Samples

Figure 5 shows that all three of the sampling groups (groundwater, spring, and geoprobe) show virtually no linear correlation and the linear relationships are all distinctly different from the linear relationship for the edge of field samples.

This lack of a common relationship between the different data sets is also apparent just from a visual examination of the graphs. For example, on the graph of dissolved copper versus dissolved phosphorus shown above (Figure 4), for copper concentrations in the range of 0.001 to 0.1 mg/L, all of the corresponding phosphorus concentrations for the groundwater samples are below 0.1 mg/L. For that same range of copper concentrations in the edge of field samples, the corresponding phosphorus concentrations are almost all greater than 0.1 mg/L.

This visual observation indicates that examining the ratios of the corresponding concentrations would better illustrate the differences between the different sample groups. Histograms of the ratio of copper to phosphorus concentrations for edge of field sample and groundwater samples are shown below.

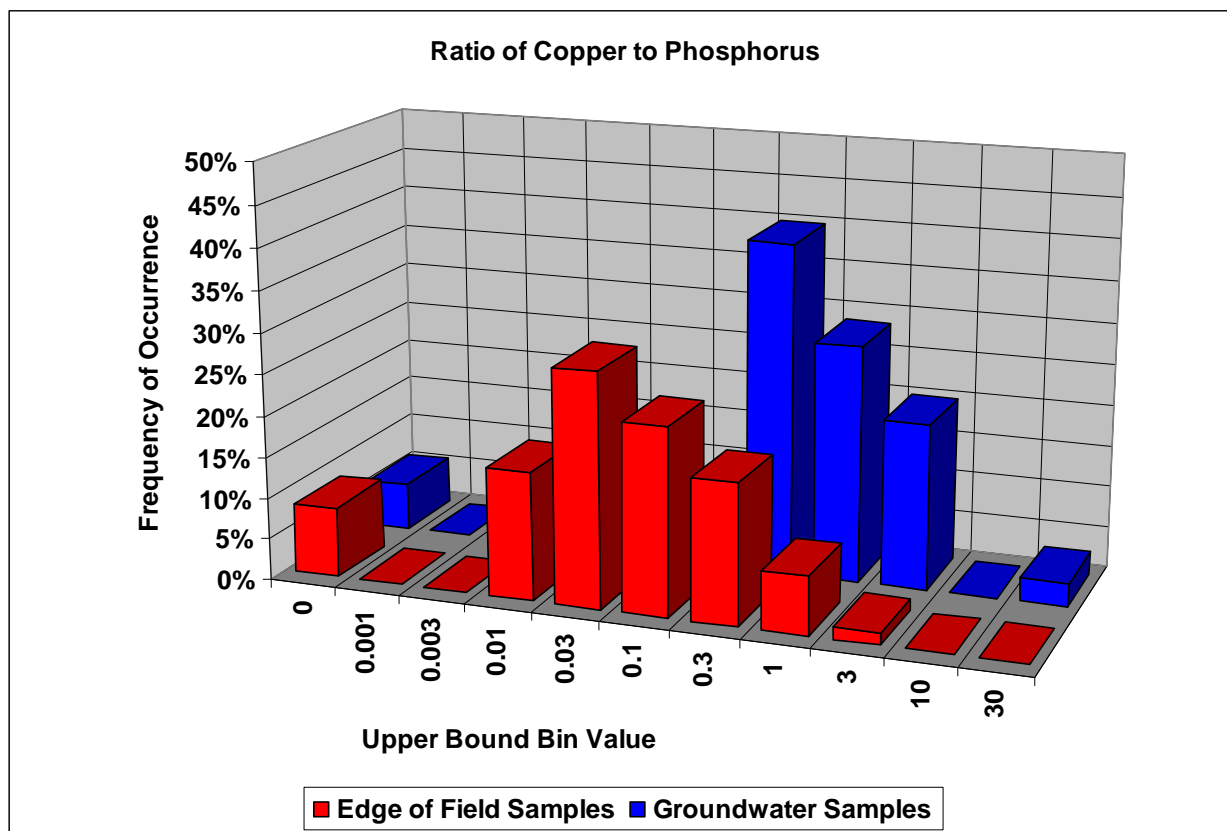


Figure 6 – Histogram of Ratios of Copper to Phosphorus Concentrations in Edge of Field and Groundwater Samples

As shown on Figure 6 above, the edge of field samples generally plot toward the left of the histogram while the groundwater samples plot toward the right. This means that the edge of field samples have a predominantly lower ratio of copper to phosphorus when compared to the groundwater samples. In fact the median ratio for the groundwater samples is more than an order of magnitude greater than the median ratio for the edge of field samples. These statistics and this figure illustrate in a more quantitative manner the differences that were apparent from the visual examination of the data plot referred to previously.

The relationship of zinc to phosphorus shows a similar difference in the ratios. Figure 7 below shows the histograms for the ratio of zinc to phosphorus concentration in the edge of field samples and the groundwater samples.

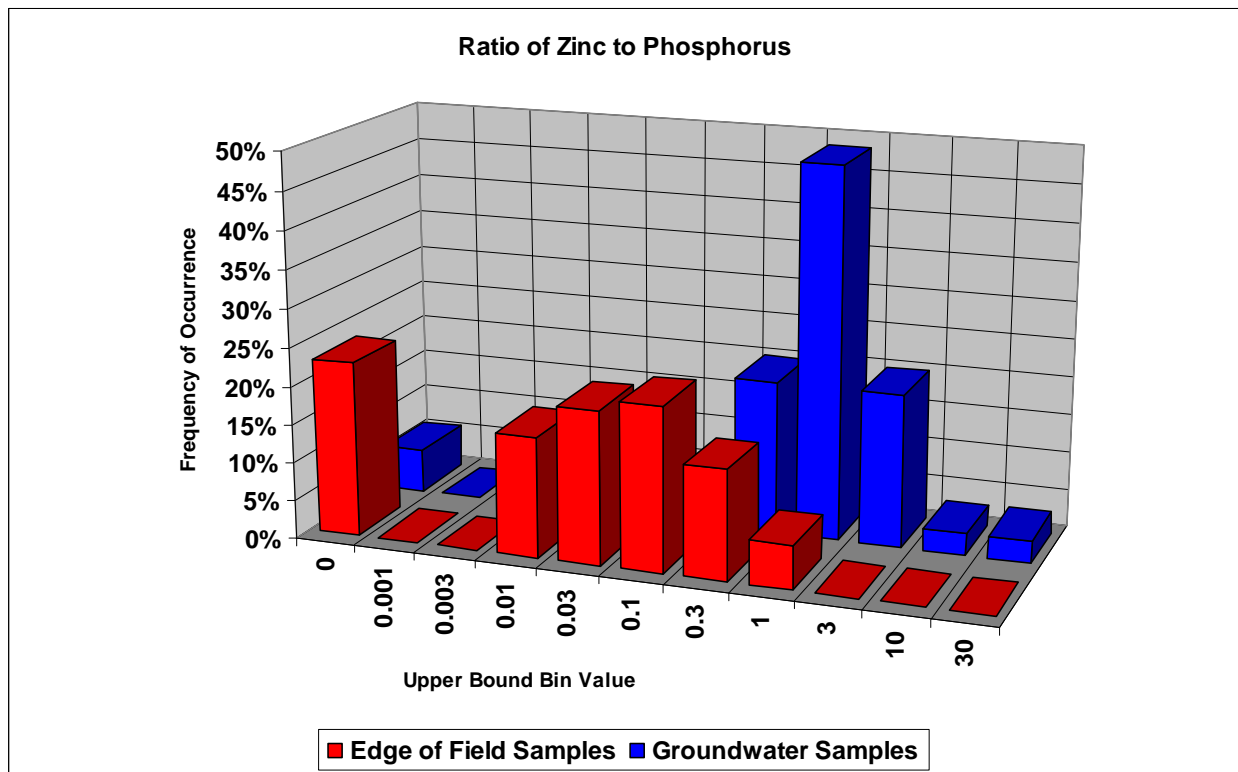


Figure 7 – Histogram of Ratios of Zinc to Phosphorus Concentrations in Edge of Field and Groundwater Samples

Again the groundwater samples plot toward the right and the edge of field samples plot toward the left indicating that the groundwater samples have a higher ratio of zinc to phosphorus than the edge of field samples. The median ratios for the two sample groups are also more than an order of magnitude apart (0.017 for edge of field samples and 0.55 for groundwater samples).

In summary, these figures show that the groundwater, spring and geoprobe sampling data do not "blend seamlessly" with edge of field samples. Under Fisher's apparent definition of "blend seamlessly," any sample with low concentrations of the different elements would qualify regardless of the actual relationship between the concentrations.

It should be noted that samples from springs and geoprobes may not be representative of groundwater pumped from wells. The water table in some areas occurs within unconsolidated materials that overlie the bedrock aquifer. The groundwater samples collected by the plaintiff consultants using the geoprobe method are from these unconsolidated materials. Groundwater from these materials has not experienced the attenuation process that can occur as the water moves into the underlying aquifer and ultimately to a well. The degree of attenuation can vary

depending on the characteristics of the pathways of the groundwater migration. Springs emerge at the ground surface and flow over land. As a result, they can be affected by surface runoff unless the sample can be collected directly from the location where the groundwater spring emerges. Observations of the spring sampling locations used by the plaintiff consultants indicated that samples could be affected by surface runoff and any contamination that might be associated with that runoff. At some spring sampling sites, cattle or other livestock were observed in or near the stream created by the spring (Conestoga-Rovers Associates, 2008). Site inspections of spring sample locations by Apex Environmental (Apex, 2008), some of which I personally attended, showed that the presence of cattle or other livestock within or near the spring flow was a common occurrence. These samples have the potential to be impacted by surface conditions that are not related to the local groundwater quality.

The correlation coefficients shown on Figure 22 of Fisher's report give the impression that the data show a strong linear correlation. Indeed, correlation coefficients approaching a value of one are an indication of strong linear correlation. In this case, however, the strength of that statistical correlation is dominated by one anomalous sample result. The reason for this fact is illustrated on the figure below.

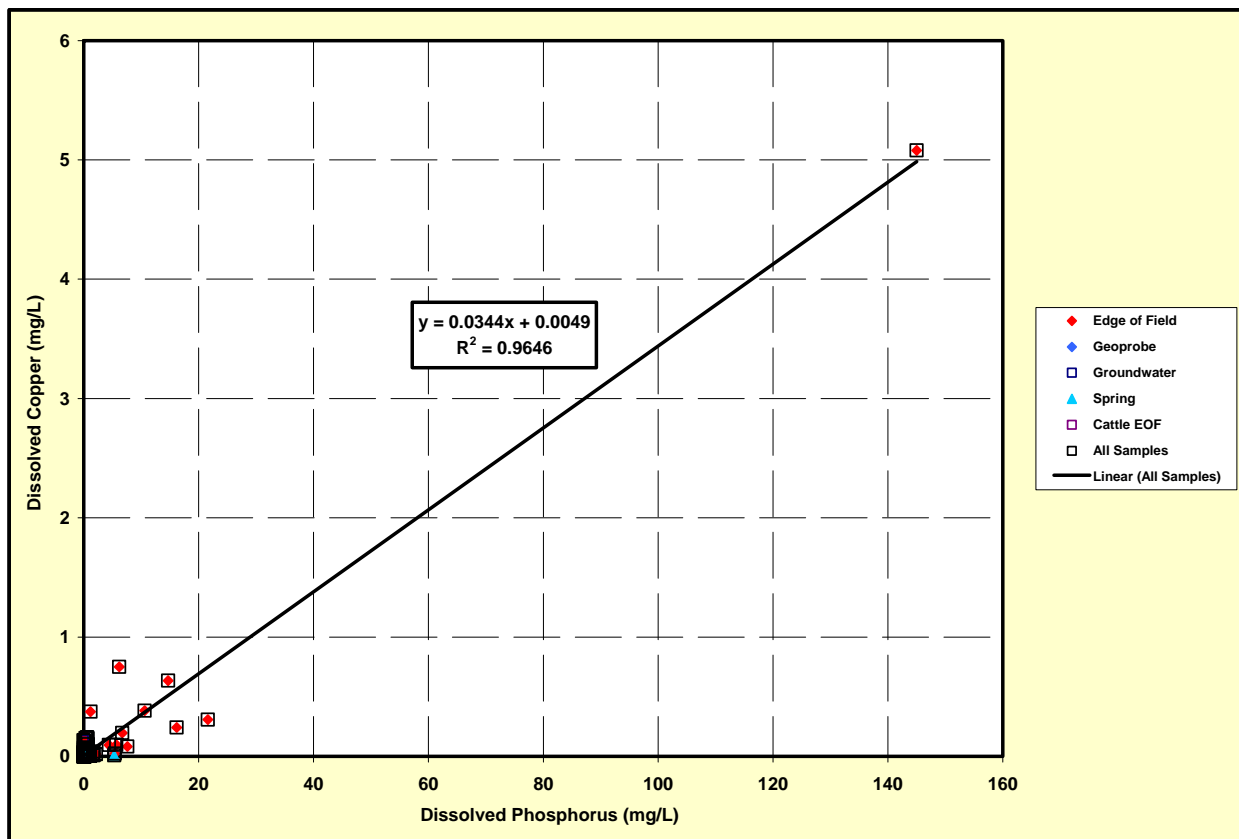




Figure 8 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Edge of Field, Geoprobe, Groundwater and Spring Samples Using Arithmetic Scales

Figure 8 shows the graph of dissolved copper and dissolved phosphorus that was discussed previously but has been displayed on *arithmetic* scales rather than the *logarithmic* scales shown previously and used by Fisher on his graphs on Figure 22. It is readily apparent from this figure that one of the samples is significantly different from all the rest. This sample is an edge of field sample that had anomalously high concentrations of dissolved phosphorus, dissolved copper, dissolve zinc and many other constituents. Sample results that are anomalous are referred to as “outliers.” The effect of outliers on correlation or other statistical measures should be tested prior to reaching statistical conclusions about the data relationships.

If the anomalous sample result is not used to characterize the linear relation in the data, the resulting correlation coefficient is markedly lower. Removing this sample from the statistical calculation produces a correlation coefficient of less than 0.5 as shown on Figure 9 below. This is a much weaker linear correlation and illustrates that the apparent strong correlation illustrated by Fisher on his Figure 22 is controlled by the single anomalous edge of field sample result.

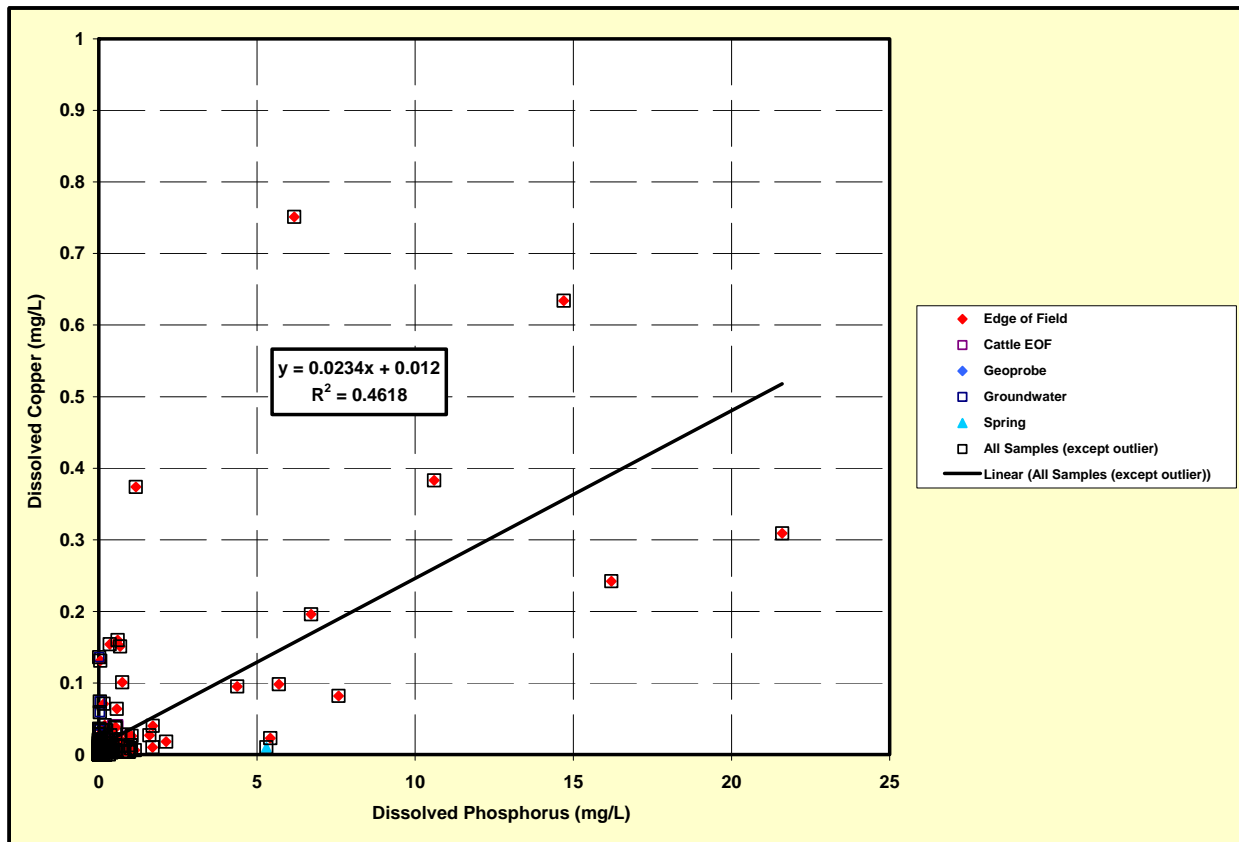


Figure 9 – Graph of Dissolved Copper versus Dissolved Phosphorus Concentrations in Edge of Field, Geoprobe, Groundwater and Spring Samples Using Arithmetic Scales without Anomalous Data Point

Plaintiff consultant, Olsen, commented on this particular sample result in his report. Olsen, on page 6-41 of his report, notes the anomalously high concentrations of several constituents found in this edge of field sample. Olsen correctly characterizes this anomalous sample result as an outlier. Olsen goes on to say that “(s)ome of the values reported seem to be laboratory errors; however; the laboratory error could not be confirmed”. Furthermore, Olsen removes this sample as an outlier and does not use the sample results in any of his principal component analysis calculations. Fisher, on the other hand, incorrectly used the sample results in spite of the fact that the sample has a disproportionate impact on the statistical calculations that he presented. This is likely the very reason that Olsen removed the sample from some of his statistical analyses.

Plaintiff consultants tried to compile information on poultry house locations to test the relationship of various sample results to poultry houses. The concept seemed to be that high correlations between measures of poultry houses such as poultry house density and sample results was an indication that sample results may be linked to the poultry houses (Olsen, p. 6-30).

While the link between sample results and poultry houses is more complicated than a simple correlation, it is worth examining this concept that plaintiff consultants have used to evaluate other data sets as it applies to groundwater sampling data.

For purposes of this examination, the poultry house density data compiled by the plaintiff consultants was used in spite of concerns over its reliability. The groundwater sample results were plotted against poultry house density data and results for the primary constituents that are claimed to be related to poultry litter are shown on the figures below.

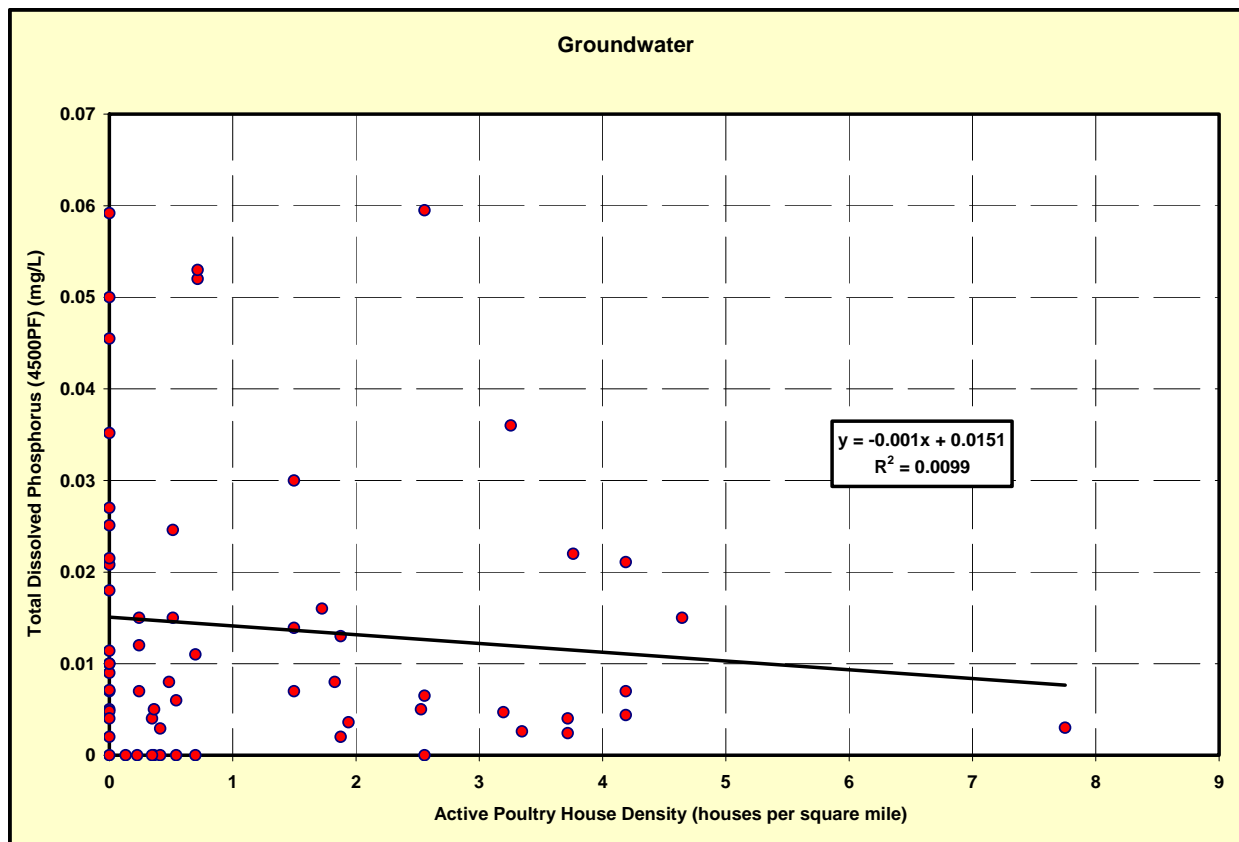


Figure 10 – Graph of Dissolved Phosphorus Concentration in Groundwater Samples versus Active Poultry House Density

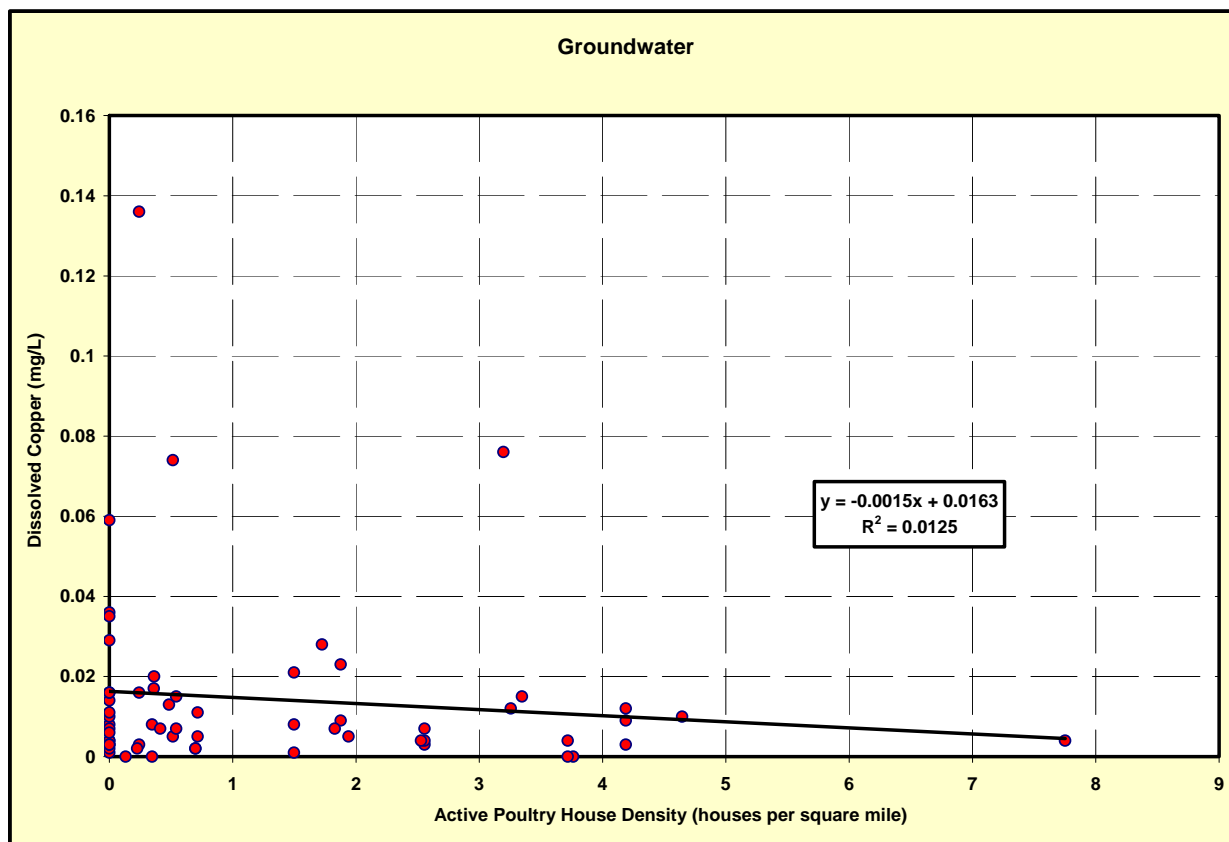


Figure 11 – Graph of Dissolved Copper Concentration in Groundwater Samples versus Active Poultry House Density

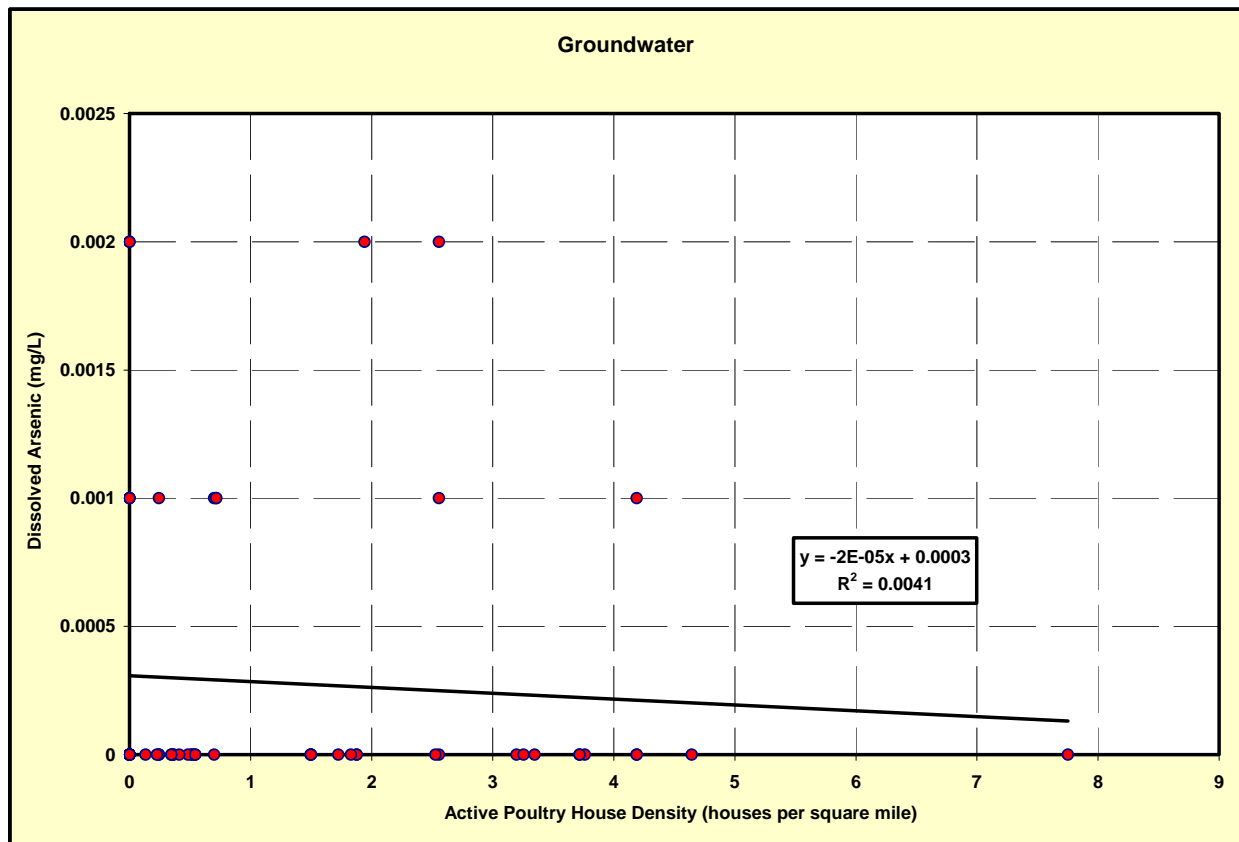


Figure 12 – Graph of Dissolved Arsenic Concentration in Groundwater Samples versus Active Poultry House Density

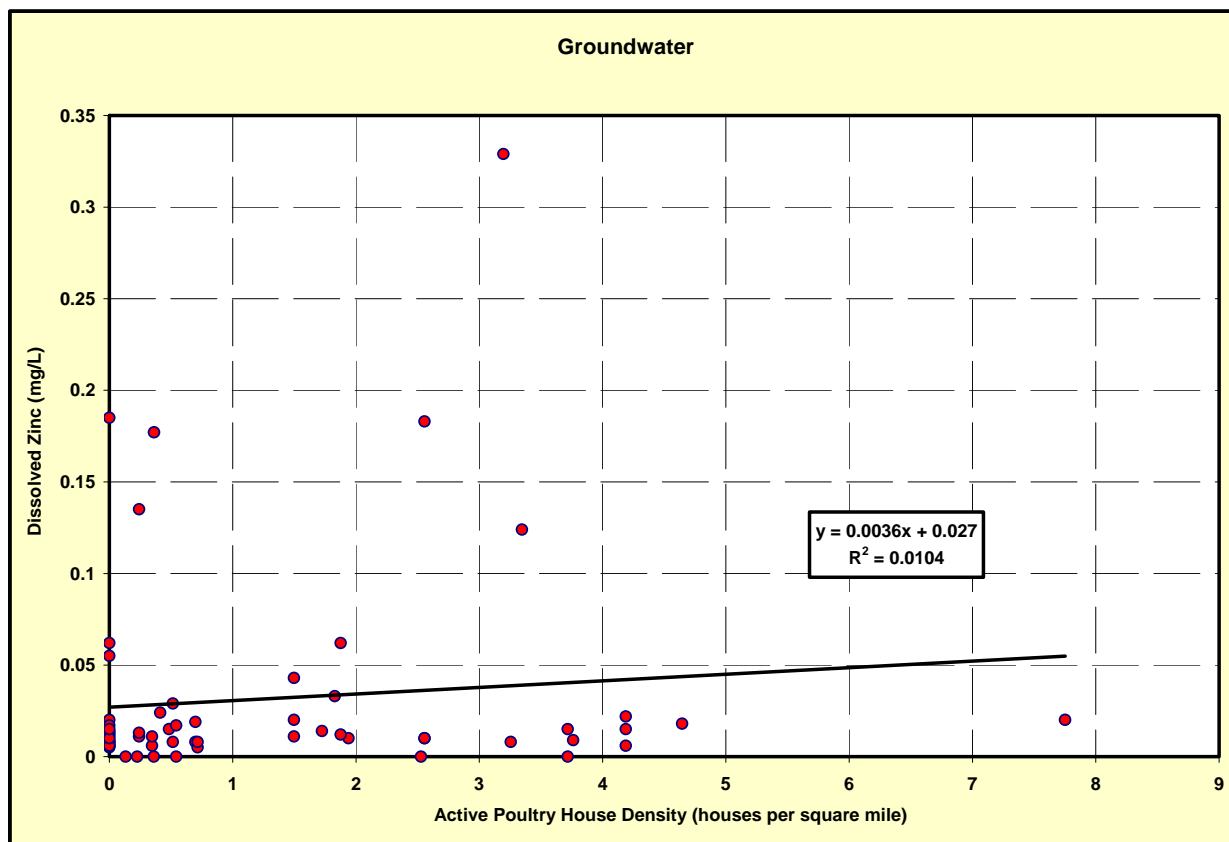


Figure 13 – Graph of Dissolved Zinc Concentration in Groundwater Samples versus Active Poultry House Density

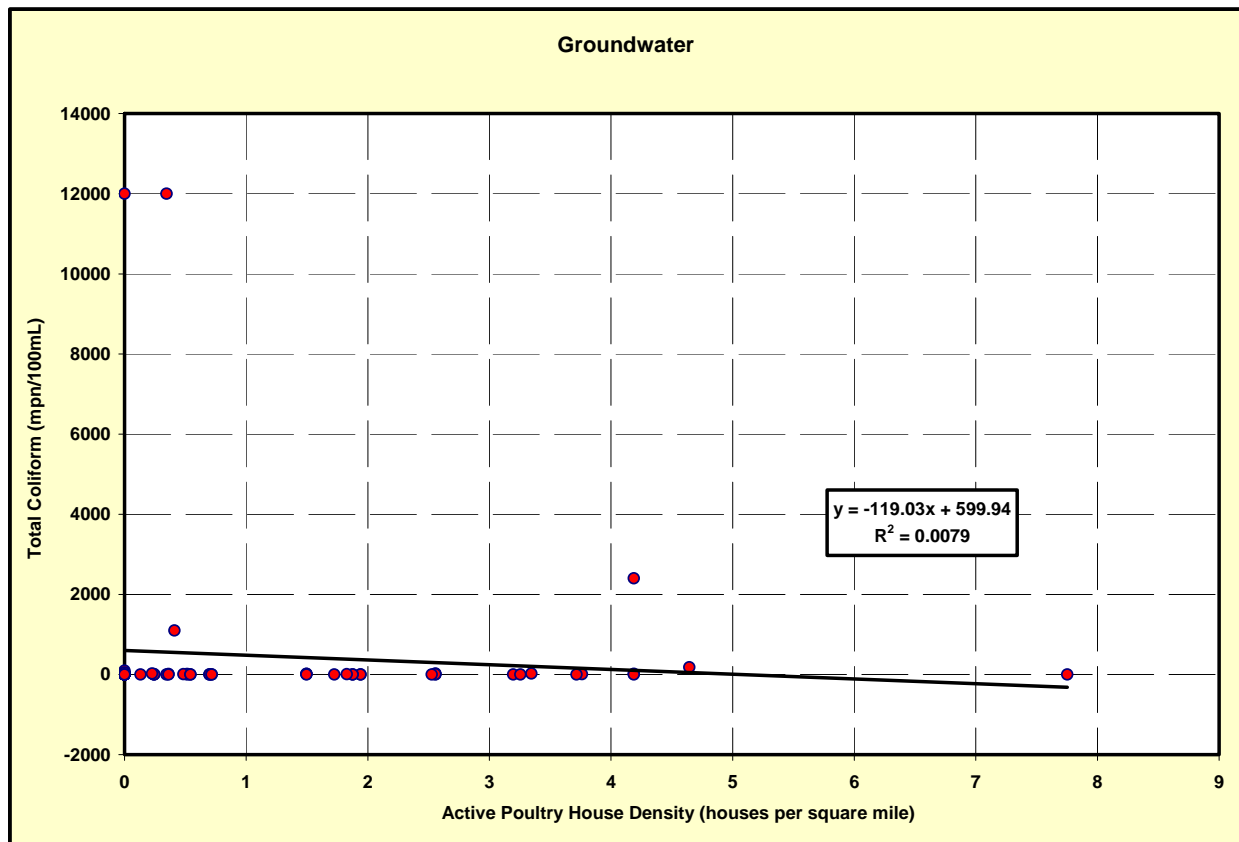


Figure 14 – Graph of Total Coliform Concentration in Groundwater Samples versus Active Poultry House Density

Figures 10 through 14 show that there is no apparent increase in concentrations of constituents such as phosphorus, zinc, arsenic, copper, or total coliform with increasing poultry house density. In other words, groundwater samples from areas with higher poultry house density do not show higher concentrations of these constituents than groundwater samples from areas with much lower poultry house density.

The statistical linear correlation coefficients confirm the visual observation. These correlation coefficients show no significant linear correlation between concentrations and poultry house density. In fact, for what it is worth, the linear relationship produced by this statistical calculation is generally decreasing. That is, it would indicate that concentrations in areas of higher poultry house density are generally lower than concentrations in areas of lower poultry house density. This decreasing trend is exactly opposite of what might be expected if there was a link between poultry houses and the groundwater concentrations. As result, these data do not provide a possible link between groundwater concentrations and poultry houses.

The lack of correlation between poultry house density and groundwater concentrations is consistent with findings of other investigators. Mugel (2002, WRI 2002-4125), conducted a

study of groundwater in the Upper Shoal Creek basin in southwest Missouri. The study was focused on evaluating if groundwater sampling data from the Springfield Plateau aquifer (the same aquifer that occurs within the Illinois River basin) demonstrated increased nutrient concentrations and fecal bacteria densities as a result of poultry confined feeding operations. The conclusion of the study was that the groundwater sampling data did not indicate an impact from poultry operations with respect to nutrient concentrations and fecal bacteria densities.

An earlier study by the U. S. Geological Survey (Adamski, 1997, WRI 96-4313) found statistical increases in some nutrient concentrations in groundwater such as nitrate associated with land use, but did not attribute the increases to a specific cause. Bacteria and nitrate can occur naturally in groundwater and can occur at elevated concentrations due to a variety of waste streams including animal waste, water treatment effluents, septic effluents, urban runoff water, fertilizers application and others. Isotopic analyses of nitrogen were made in the more recent U. S. Geological Survey study (Mugel, 2002, WRI 2002-4135) and indicated that nitrogen may be a mix of effects from animal and human waste and commercial fertilizer.

When functioning properly, septic tank effluent can also be a source of nitrogen and bacteria to groundwater. Normal septic tank operation would be expected to remove only a small portion (10 to 20 percent) of the nitrogen from the influent (USEPA, 2002). The remaining nitrogen can readily migrate to groundwater as nitrate since septic tank infiltration fields are typically several feet below ground surface. As noted in the USEPA report, nitrate contamination of groundwater from septic systems has been shown by many studies.

Septic system malfunctions result in the release of untreated or partially treated septic waste directly onto the land surface and/or into the shallow subsurface. Septic waste typically contains significant concentrations of nitrogen, phosphorus, bacteria and other chemicals. Domestic wastewater can contain nitrogen, phosphorus and bacteria at significant concentrations. USEPA (USEPA, 2002) reports that septic waste can contain nitrogen concentrations ranging from 10 to 100 mg/L, phosphorus concentrations ranging from 5 to 15 mg/L and bacteria (fecal coliform) concentrations ranging from 10^6 to 10^8 organisms per 100 mL. These concentrated waste discharges have the potential to materially impact surface water and shallow groundwater.

Septic tanks are used by over 76,000 residents within the Illinois River Basin (Sullivan, 2008). In addition, residents in rural areas often rely on wells for water supply that are in relatively close proximity to septic tanks and/or septic system infiltration fields. This makes septic tank effluent a significant potential source of well contamination. The capture zone (area that encompasses where a well draws its water from) for domestic supply wells can be relatively small and very localized. For example, a well pumping 200 gallons per day in a location where groundwater recharge (infiltration) averages 6 inches per year would draw its water from an area of less than 0.5 acres. This recharge area will often be near and immediately upgradient from the well. Residential septic tanks and infiltration fields and residential wells are typically located near the dwelling that they serve. As a result, septic tanks and infiltration fields and wells are typically within a few hundred feet of one another. This proximity makes it likely that some residential wells can capture groundwater that recharges in the area of the septic tank and

infiltration field. Thus, septic tanks represent a much greater potential source of well contamination than other potential sources that are located at greater distances from the well.

Septic tank systems can often fail or malfunction and allow domestic wastewater to discharge directly onto or into the ground. The failure rate for septic tank systems within the Illinois River watershed is significant. The Illinois River Basin Plan indicates that it is likely that as many as 75% of the on-site waste disposal systems are inadequately constructed or located (Haraughty, 1999). A survey of septic systems in Tontitown and Highfill, Arkansas, indicated that 74 out of 171 septic tank systems (43%) had some type of reported failure (Engineering Services, Inc., 2004). Plaintiff consultants (Teaf, 2008) assumed an 8% failure rate in their assessment of potential impacts from septic tanks based on a study in the Texas Panhandle (Parsons, 2006). This study recognized the potential impact of malfunctioning septic systems with regard to fecal coliform contamination of groundwater and surface water and was attempting to estimate the magnitude of that contamination. The studies of conditions within the Illinois River Basin indicate a much higher failure rate than the value assumed in the Canadian River study and the value used by the plaintiff consultants.

Contamination of domestic wells by bacteria in rural agricultural environments is not uncommon. A comprehensive study by the U. S. Geological Survey (Embrey and Runkle, 2006, WRI 2006-5290) of the microbial quality of groundwater throughout the United States showed that the occurrence of bacterial contamination in wells was common and can exceed 50% in some areas. The study found that the occurrence of fecal-indicator bacteria in groundwater was widespread geographically and were found in almost 30% (347 out of 1,174) of the samples used in the study.

Studies of bacterial contamination of groundwater in the Illinois River basin over the past decades have shown similar detection frequencies. In a 1972 study in which 50 wells in Benton and Washington Counties were sampled, 74% of the wells tested positive for fecal coliform (Kenner, 1972). In a 1975 study of Washington County, in which groundwater samples from 47 wells were analyzed for bacteria, samples from 18 wells (38%) contained fecal coliform (Coughlin, 1975). A study of groundwater in Benton County, Arkansas in 1980 reported that total coliform was detected in 68% of the samples and fecal streptococcus was detected in 49% of the samples. These results indicate that conditions in the Illinois River basin several decades ago were similar with respect to the detection frequency of bacteria contamination to that found in the recent sampling of wells conducted by the plaintiff consultants.

The phosphorus concentrations found in groundwater samples from wells in the Illinois River basin are typical of concentrations found in groundwater environments associated with carbonate aquifer systems. The U.S. Geological Survey (USGS Water Data Website) has compiled data on groundwater concentrations for a variety of constituents in numerous aquifer systems throughout the United States. These data show that the magnitude and distribution of dissolved phosphorus concentrations in the groundwater samples from the Illinois River basin are similar or even lower than the magnitude and distribution of concentrations found in

comparable aquifer systems elsewhere in the United States. The figure below illustrates the data on dissolved phosphorus obtained from the U. S. Geological Survey data base.

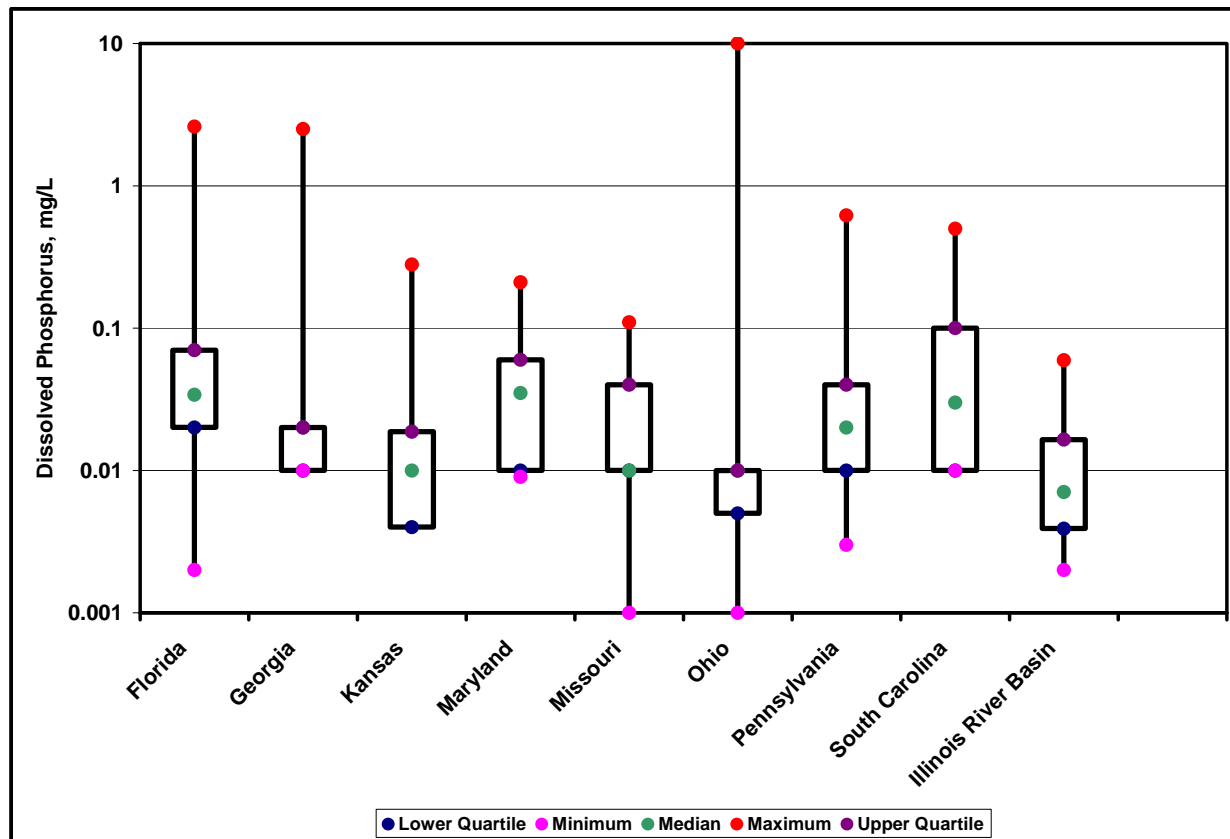


Figure 15 – Boxplot of Dissolved Phosphorus Concentration Distributions in Groundwater Samples in Carbonate Aquifer Systems Located in Different Parts of the United States

Figure 15 is referred to as a boxplot (Helsel and Hirsch, 2002), and is a convenient way to compare different sets of data. The boxplot includes the median concentration, the maximum and minimum concentrations, and the interquartile range (the “box” from the 25th percentile value to the 75th percentile value). The plot clearly shows the range of the data and the span of values about the median where half of the values occur. As shown on this figure, the data for groundwater samples collected from the Illinois River basin is well within the range of data from similar aquifer systems in other parts of the United States. It also shows that the central values or interquartile range of the phosphorus concentrations in the groundwater samples collected from the Illinois River basin are lower than that found in most of the other states.

Plaintiff consultant King, in his report and in deposition (page 227) assumed that any detection of bacteria in a groundwater sample from a well was caused by poultry operations. This assumption is not supported by the sampling data or by any of the other plaintiff consultant reports. As discussed previously, plaintiff consultant Fisher's attempt to link groundwater sample

results to edge of field sample results and thus to poultry operations has no technical basis. Sampling data from throughout the United States show that the detection frequency of bacteria in the plaintiff groundwater samples from the Illinois River basin is no different and is even less than that found in comparable hydrogeologic environments.

It is worth noting that plaintiff groundwater samples containing fecal coliform are not different from samples that do not contain fecal coliform with respect to other constituents that plaintiff consultants contend are fingerprints of poultry litter. If the sample data are divided into two groups; samples from wells in which fecal coliform was detected and samples from wells in which fecal coliform was not detected, the constituents that are alleged to be fingerprints of poultry litter can be compared. In the plaintiff samples from wells, the median concentrations of alleged fingerprint constituents such as arsenic, copper, zinc, and phosphorus were not elevated in one group versus the other group. If elevated concentrations of these alleged fingerprint constituents are a reliable indicator that groundwater has been impacted by poultry litter, there is no evidence that the wells containing bacterial contamination have been impacted by poultry litter.

Plaintiff consultant King (King, 2008) uses the frequency of detection for bacteria and nitrate in the well samples to compute how many of all of the wells used for drinking water supply in the Illinois River basin must be replaced or otherwise treated. However, there is no technical basis to link bacteria detections or nitrate concentrations above the MCL to poultry litter. In fact, in deposition testimony, King testified that he was not prepared to opine that the contamination of the wells that he refers to was a direct result of poultry litter. Even apart from that fact, the application of the detection frequency in the plaintiff well samples to all of the wells in the basin is problematic. Since the wells were only sampled once, there is no information about the persistence of the conditions in each well over time. The federal secondary drinking water regulation for total coliform that applies to public water supply systems is specified as a percentage of samples over time that can test positive (USEPA, 2001). The plaintiff sampling data are not sufficient to determine whether these wells would or would not meet that requirement.

Plaintiff consultant Olsen conducted several statistical analyses of various sampling data using principal component analysis in an attempt to identify samples that were impacted by poultry litter. One of these analyses (referred to as SW 17) included groundwater samples among the various groups of samples that were included in the analysis. In his report, Olsen (p. 6.61) concludes that values of principal component one (PC1) that exceed 1.3 means that the sample has been impacted by poultry contamination. He also concludes that values of principal component two (PC2) that exceed 4.7 means the sample has been impacted by waste water treatment plant effluent.

The veracity of Olsen's principal component analysis for distinguishing sources of impact to the various sample groups is highly questionable and is discussed in detail by other investigators (Johnson, 2008). From a qualitative viewpoint, the analysis gives the appearance of statistical rigor but the ultimate conclusion offered by Olsen is actually very subjective. As

described below with respect to groundwater samples, Olsen's subjective determinations of PC score values do not make sense or, at the very least, have no discriminatory value. However, Olsen's PC score determinations are discussed below to show that the analysis is not a reliable indicator of impacts to groundwater and, even if they were, they are inconsistent with the assumptions made by King regarding groundwater impacts related to poultry litter.

Sampling data show that the distribution of phosphorus concentrations in groundwater samples that Olsen determined were impacted by poultry contamination is the same as the distribution of phosphorus concentrations in groundwater samples that are categorized as not impacted by poultry. These data are illustrated in the figure below.

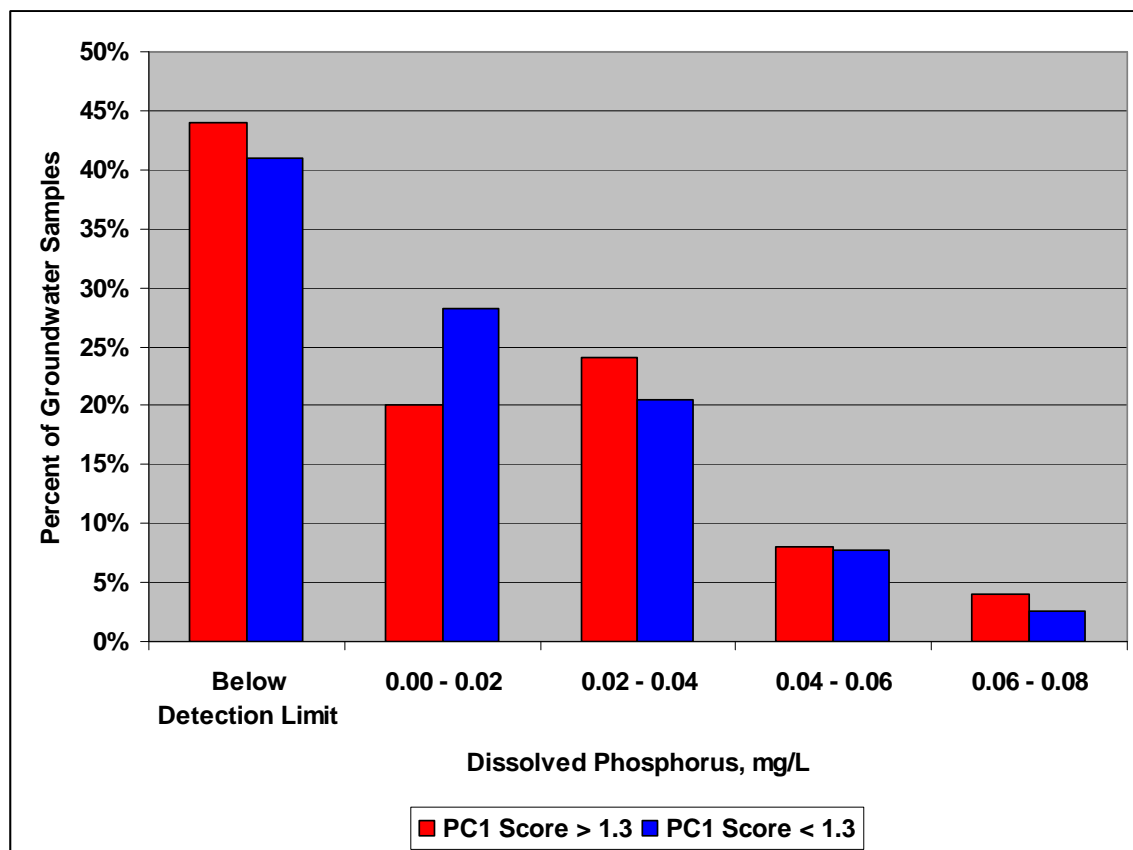


Figure 16 – Histograms of Dissolved Phosphorus Concentrations in Groundwater Samples Grouped by PC Scores

Figure 16 shows two things. First, the dissolved phosphorus concentrations in the groundwater samples are low. Second, the frequency of occurrence in phosphorus

concentrations in the various ranges displayed on the figure is essentially the same whether the PC1 score is above 1.3 or below 1.3. This illustrates that groundwater samples characterized by Olsen as poultry impacted do not have phosphorus concentrations that are higher than phosphorus concentrations in groundwater samples that he characterizes as not impacted by poultry. Thus the PC1 score does not provide a reliable indicator of any impact to groundwater with regard to phosphorus.

The same conclusion regarding lack of reliability in the PC score indicator is true for bacteria occurrence in groundwater samples. For example, groundwater sampling data shows 11 occurrences of fecal coliform. Six of those occurrences are in groundwater samples with a PC1 score greater than 1.3 and five are in groundwater samples with a PC1 score less than 1.3. Again the PC1 score above or below 1.3 is not a reliable indicator of whether a sample is likely to contain fecal coliform.

It is worth noting that Olsen's conclusions regarding the PC scores are not consistent with plaintiff consultant King's assumptions about poultry impacts. King assumed that any detection of total coliform in a groundwater sample was associated with poultry impacts. In his report, King cites to groundwater sampling data to conclude that 36 of 60 private wells were impacted by bacteria from poultry (page 7 of 36). The groundwater sampling data shows that 34 samples reported total coliform. The count of 36 samples referred to by King includes all bacterial forms, but most of the detections that are referred to are associated with total coliform.

Of the 34 groundwater samples that tested positive for total coliform, Olsen's PC analysis indicates that only 17 of those samples has a PC1 score above 1.3. In other words, Olsen concludes that only half of the 34 samples testing positive for total coliform indicate a potential poultry impact while King assumes that all 34 samples have been impacted by poultry.

In fact, some of the samples that have a PC1 score above 1.3 also have a PC2 score above 4.7. Other investigators (Johnson, 2008) have evaluated Olsen's PC analysis in detail and have prepared a graph that depicts the relationship between PC1 and PC2 scores for the groundwater samples. This graph shows that only 9 samples have PC1 scores above 1.3 and PC2 scores less than 4.7. Olsen characterizes the 9 samples with PC1 scores above 1.3 and PC2 scores below 4.7 as predominantly poultry impacted. Other samples with a PC1 score above 1.3 have a poultry impact but it is not the predominant impact. Eight of the nine samples have detections of bacteria. Therefore, to be consistent with Olsen, King would have to assume no more than 8 of groundwater samples with detections of bacteria could be related predominantly to poultry impacts.

King also assumes that wells with groundwater samples containing nitrate concentrations above 10 mg/L need to be treated or replaced. He cites to the sampling data that indicates 8 of 60 groundwater samples contain nitrate concentrations above 10 mg/L. The basis for 8 of 60 groundwater samples with nitrate concentrations above 10 mg/L is unclear as the database only includes 5 of 60 groundwater samples with nitrate concentrations above 10 mg/L. However, more importantly, all of the 5 samples with nitrate concentrations above 10 mg/L had PC2 scores above 4.7. According to Olsen's criteria, these samples are not impacted predominantly by

poultry. Again, King has made an assumption about the origin of contamination in groundwater samples that is not consistent with Olsen's PC analysis.

In general, groundwater samples are likely to be incompatible with the PC analysis used by Olsen. Concentrations of many constituents in groundwater are unlikely to behave in a conservative manner, especially for constituents such as copper, zinc, arsenic, and phosphorus that might be associated with poultry litter. This means that in the groundwater environment, these constituents will interact with the solid materials in different ways and that interaction will affect the relative concentrations at different locations in the groundwater. Any changes in the groundwater concentrations caused by this interaction may cause the PC analysis results to make the groundwater samples look more or less like other samples in the total population. This would lead to an erroneous conclusion of similarity or disparity with the other samples that is really simply an artifact of the groundwater interacting with its environment.

The problem with Olsen's PC analysis with respect to groundwater is evidenced by examining the spatial patterns of the PC1 and PC2 scores for the groundwater samples. For example, when the PC2 scores for groundwater samples from wells are plotted on a map of the basin, many, if not most, of the wells where groundwater samples had a PC2 score above 4.7 are not in a position to be impacted by discharge from waste water treatment plants (see Johnson, 2008). These wells might be in a location where they could be impacted by human waste from septic tanks but not by waste water treatment effluent. Similarly, when the PC1 scores for groundwater samples are plotted on maps depicting poultry house, many of the wells are not in a location where poultry houses or litter application have the potential to create an impact.

In general, the PC analysis presented by Olsen gives the misleading impression that most of the groundwater within the Illinois River Basin has been adversely affected, either by poultry litter and/or by waste water treatment plant effluent, and cannot be used for drinking water supply. The actual sampling data do not support this impression. For the most part, the groundwater quality as represented by the samples collected by the plaintiff consultants meets USEPA drinking water standards. Exceptions to this generalization include a limited number of samples where the 10 mg/L nitrate standard is exceeded and the occurrence of total coliform and fecal coliform. As discussed previously, the limited number of nitrate exceedances is not predominately related to poultry litter according to Olsen's own analysis and this frequency of exceedance is not uncommon for the types of land use in the basin. With regard to detections of coliform and/or fecal bacteria, additional sampling is necessary to determine whether drinking water standards have not been met. Their occurrence is not a specific health threat but is used to indicate whether pathogens may be present.

Nutrient management practices, as described in nutrient management plans for fields in Oklahoma and Arkansas, significantly reduce the potential for impacts to groundwater from the application of poultry litter. The guidelines and considerations established or utilized for nutrient management plans include provisions that are directly aimed at minimizing or eliminating conditions that have the potential to impact groundwater, among other things. These provisions include offsets between nutrient application and public or private wells to reduce or eliminate the



potential for contaminant infiltration in an area where that infiltration might be entrained in the groundwater withdrawn from the well. They also include provisions to avoid application near perennial ponds or sinkholes that might be in direct communication with groundwater and provisions regarding the nature and thickness of soil cover to minimize the potential for infiltration to groundwater and maximize the potential for adsorption within the soil column. Guidelines also call for determinations of application rates that are “protective” in that they can provide for appropriate crop requirements and prevent significant impact to groundwater and surface water. By observing these guidelines and considerations, the potential for impacts to groundwater from the application of poultry litter is significantly reduced.

Section 4

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January 16.

APPENDIX



STEVEN P. LARSON

Groundwater Hydrologist

EDUCATION	MS Civil Engineering, 1971, University of Minnesota, Minneapolis, Minnesota BS Civil Engineering (with high distinction), 1969, University of Minnesota, Minneapolis, Minnesota
REGISTRATIONS	Certified Professional Hydrologist American Institute of Hydrology
PROFESSIONAL HISTORY	S.S. Papadopoulos & Associates, Inc. , Bethesda, Maryland Executive Vice President, 1980-present U.S. Geological Survey , Water Resources Division, Reston, Virginia Hydrologist, 1975-1980 U.S. Geological Survey , Water Resources Division, St. Paul, Minnesota Hydrologist, 1971-1975 U.S. Geological Survey , Water Resources Division – National Training Center, Denver, Colorado Hydrologist, 1971 St. Anthony Falls Hydraulic Laboratory , Minneapolis, Minnesota Research Assistant, 1969-1971
SUMMARY OF QUALIFICATIONS	<p>Mr. Larson is a recognized authority on numerical simulation models and their application in the analysis of a variety of groundwater problems. He has developed such models for analyzing groundwater flow, mass- and heat-transport in groundwater systems, contaminant migration, recovery of petroleum products from groundwater, saltwater intrusion in coastal aquifers, and thermal energy storage in aquifers. In addition, he has been in the forefront of combining these methods with linear programming techniques to optimize the development of groundwater supplies or remediation of contaminated groundwater. He has conducted training courses on the use of these models and provided technical support on their application to a variety of hydrologic conditions. Mr. Larson has authored and co-authored publications on the application of aquifer simulation models that are widely used by practicing hydrologists. He has served as an expert witness in numerous judicial forums regarding groundwater issues and the application of simulation models for demonstrating the fate of soil/groundwater contamination and the effect of remediation alternatives.</p>
AWARDS & HONORS	Civil Servant of the Year , U.S. Geological Survey, 1974 U.S. Geological Survey Incentive Award , 1974 American Society of Civil Engineering Student Award , 1969
REPRESENTATIVE PROJECT EXPERIENCE	S.S. Papadopoulos & Associates, Inc. , Bethesda, Maryland As senior principal of the company, Mr. Larson assists in the management of the company and in the conduct and management of projects dealing with a wide variety of environmental and water-resource issues. During his many years at SSP&A, he has been involved in numerous projects covering a wide spectrum of technical, environmental, and legal issues including: <ul style="list-style-type: none"> Site evaluations for remedial investigations, feasibility studies, engineering evaluation/cost analyses, or remedial action plans at CERCLA and other waste disposal sites including the Stringfellow site in California, the FMC Fridley site in Minnesota, the Chem Dyne site in Ohio, the Conservation Chemical site in



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REPRESENTATIVE PROJECT EXPERIENCE — continued

- Missouri, the Hardage-Criner site in Oklahoma, and the Hastings site in Nebraska.
- Evaluations of groundwater contamination at CERCLA and other waste-disposal sites including Love Canal, New York; Savannah River Plant, South Carolina; Tucson Airport, Arizona; Ottati & Goss site, New Hampshire; Martin-Marietta site, Colorado; and Western Processing site in Washington.
 - Environmental impact evaluations of the effects of water development for proposed coal slurry operations in Wyoming, of in-situ mining for trona minerals in Wyoming, and of groundwater development on the shallow-water-table in South Dakota.
 - Evaluations of the effects of discharge on groundwater from chemical-manufacturing waste disposal in Wyoming, Virginia, and New York.
 - Water-supply development evaluations, including potential impacts of salt water intrusion on water supply development, in Oman, Portugal and in Florida; and analysis of potential impacts of power plant cooling water on groundwater and surface water in Wyoming.
 - Evaluations of permitting, licensing, and environmental issues associated with coal mining in Wyoming, Montana, and Arizona, copper mining in Montana and Utah, trona mining in Wyoming, and uranium mining in New Mexico.
 - Evaluations of water-rights permitting and adjudication in New Mexico, Texas, Colorado, Kansas, Wyoming, Nebraska, Arizona, and Idaho.
 - Environmental audits, groundwater monitoring plans, and other environmental investigations at the Oaks Landfill in Maryland, the FMC Carteret facility in Wyoming, the former IBM facility in Indiana, and the Insilco site in Florida.

SPECIFIC PROJECT EXPERIENCE

- Far-Mar-Co Subsite, Hastings Superfund Site, Nebraska – Supervised the preparation of an engineering evaluation/cost analysis (EE/CA) to support implementation of remediation of groundwater contamination. Worked with regulatory agencies to gain approval of the EE/CA and progress toward design and implementation. Previously, on behalf of Morrisson Enterprises, supervised completion of a remedial investigation and a feasibility study which focused on carbon tetrachloride and ethylene dibromide contamination.
- Stringfellow site near Riverside, California – Served as the principal technical advisor on groundwater issues to the Pyrite Canyon Group, which overviewed investigations and remedial activities sponsored by the responsible parties. Designed and evaluated several investigations and remediation programs. Represented the client as a technical spokesperson in workshops, technical seminars, and meetings with regulatory agencies and other interested parties. Prepared key documents to support the decision-making process toward the final Record of Decision.
- In the case of Kansas v. Colorado before the U.S. Supreme Court – Served on a team of technical advisors to the State of Kansas in its litigation with Colorado over violations of the Arkansas River Compact. Assisted in obtaining a finding



STEVEN P. LARSON

Groundwater Hydrologist

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**REPRESENTATIVE
PROJECT
EXPERIENCE**
— *continued*

of compact violation regarding the pumping of groundwater from wells along the river valley in Colorado. Continues as a technical expert as the case moves into subsequent phases involving the quantification of depletions of supply, assessments of damage, and future compliance by Colorado.

EXPERT AND FACT WITNESS EXPERIENCE

- Litigation associated with soil and groundwater contamination at CERCLA, RCRA, and other facility sites in California, Kansas, Missouri, Oklahoma, Tennessee, Montana, Florida, Iowa, and Nebraska.
- Toxic tort, property damage, and liability litigation regarding soil and groundwater contamination at sites or facilities in New York, Tennessee, Texas, Virginia, Ohio, and other states.
- Insurance recovery litigation associated with contamination at a variety of sites or facilities for commercial clients such as General Electric, FMC Corporation, Upjohn, AT&T, Rohr Industries, Beazer East/Koppers, North American Phillips, DOW Chemical, Occidental Chemical, and Southern California Edison.
- Water-rights permitting litigation and water adjudication including cases in New Mexico, Colorado, and Arizona, as well as interstate river compact disputes involving the states of Kansas, Colorado, Wyoming, and Nebraska.

U.S. Geological Survey, Water Resources Division, Reston, Virginia

Originated, planned and conducted research in the development of numerical simulation models and techniques for the analysis of a variety of problems related to groundwater systems. Mr. Larson applied the developed models to actual field situations for verification and further refinement, and documented these models in a manner suitable for use by others. He served as coordinator and instructor for training courses on groundwater simulation models and methodologies conducted by the Division, and provided primary technical assistance to many groundwater projects conducted by District. Mr. Larson participated in and represented the U.S. Geological Survey in national and international meetings. He conducted groundwater studies of national and regional interest and participated in, or was detailed to, overseas projects conducted or managed by other U.S. agencies and the World Bank.

U.S. Geological Survey, Water Resources Division, St. Paul, Minnesota

Served as Project Chief and participated in studies involving the evaluation of groundwater resources, the assessment of stream-water quality, and the analysis of surface-water/groundwater relationships in various parts of Minnesota.

U.S. Geological Survey, Water Resources Division, National Training Center, Denver

Participated in an extended training program providing in-depth training on both office and field techniques for the collection and the analysis of data and the conduct of surface-water, groundwater, and water-quality studies.

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Groundwater Hydrologist

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**REPRESENTATIVE
PROJECT
EXPERIENCE**
— continued**St. Anthony Falls Hydraulic Laboratory**, Minneapolis, Minnesota

As a Research Assistant, participated in the development and operation of an urban-runoff model to predict sewer flow distribution for the Minneapolis – St. Paul Sanitary District. Assisted in runoff prediction studies for St. Paul and participated in a project to survey and summarize computer programs used in water resources engineering.

**PROFESSIONAL
SOCIETIES**

Association of Ground Water Scientists and Engineers
American Institute of Hydrology
Chi Epsilon

**PUBLICATIONS
PREVIOUS 10 YEARS**

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PREVIOUS FOUR
YEARS****DEPOSITIONS**

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**DEPOSITION AND
TESTIMONY
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— continued

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- 2005 Rodney Montello et al. vs. Alcoa Inc. et al. vs. Whittaker Corporation. United States District Court for the Southern District of Texas, Victoria Division. C.A. No. V-02-84. December 19.
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- 2005 Santa Fe Pacific Gold Corporation vs. United Nuclear Corporation vs. The Travelers Indemnity Company and Century Indemnity Company, Inc. Eleventh Judicial District Court, County of McKinley, State of New Mexico. Case No. CV-97-139II. September 8.
- 2005 Nathaniel Allen et al. vs. Aerojet-General Corporation et al. Superior Court of the State of California for the County of Sacramento. Case No. 98AS01025. August 29.
- 2005 Aerojet-General Corporation vs. Fidelity & Casualty Co. of New York et al., Aerojet-General Corporation vs. Commercial Union Insurance Company, as Successor-In-Interest to Employers' Surplus Lines Insurance Company, etc. et al. Superior Court of the State of California in and for the County of Sacramento. Case No. 527932. July 20.
- 2005 United States of America vs. Jay James Jackson et al. U.S. District Court for the District of Nebraska. Case No. 8:04CV64. June 9.
- 2005 Palmisano vs. Olin Corporation. U.S. District Court, Northern District of California, San Jose Division. Case No. 5:03-cv-01607-RMW. March 7.
- 2005 Cheryl Lanoux et al. vs. Crompton Manufacturing Company et al. 23rd Judicial District Court, Parish of Ascension, State of Louisiana. Suit No. 72,897, Division: "B". February 25.
- 2004 RHI Holdings, Inc. vs. American Employers Insurance Company. Commonwealth of Massachusetts Superior Court Department. Civil Action No. 01-5443-G. December 7.
- 2004 Massachusetts Electric Company et al. vs. Travelers Casualty & Surety Company et al. Commonwealth of Massachusetts Superior Court. Civil Action No. 99-00467B. November 18-19.
- 2004 PECO Energy Company vs. Insurance Company of North America, et al. Court of Common Pleas of Chester County, Pennsylvania. Case No. 99-07386. June 14-15.



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**DEPOSITION AND
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— *continued*

2004 Kerr-McGee Corporation and Kerr-McGee Chemical, LLC, vs. Hartford Accident and Indemnity Company and Liberty Mutual Insurance Company. Superior Court of New Jersey Law Division: Somerset County. Docket No.: SOM-L-229-01. May 26.

TESTIMONY

2007 City of Neodesha, Kansas et al. vs. BP Corporation North America. District Court of Wilson County, Kansas. 2004-CV-19. December.

2006 Nikko Materials USA, Inc., dba Gould Electronics v. NavCom Defense Electronics Inc., Ernest Jarvis, and Hyrum Jarvis. United States District Court, Central District of California. CV05-4158-JFW (VBKx). December 7.

2006 Rules Governing New Withdrawals of Ground Water in Water Division 3 Affecting the Rate or Direction of Movement of Water in the Confined Aquifer System AKA "Confined Aquifer New Use Rules for Division 3" in Alamosa, Conejos, Costilla, Rio Grande, and Saguache Counties. District Court, Water Division No. 3, Colorado. Case No. 2004CW24. March.

2005 Goodrich Corporation vs. Commercial Union Insurance Company et al. In the Court of Common Pleas, Summit County, Ohio. Case No. CV 99 02 0410. December.

2005 Redlands Tort Litigation. Superior Court of the State of California for the County of San Bernardino. No. RCV 31496. March 21-22.

2004 Waste Management, Inc. et al. vs. The Admiral Insurance Company et al. Superior Court of New Jersey Law Division: Hudson County. Case No. HUD-L-931-92. January 6



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Rate of Compensation:

Mr. Larson's rate of compensation is \$272.00 per hour.